National Defence / Défense nationale

COMPARISON OF GORETEX LAMINATED AND DERMOFLEX COATED FABRICS

by

P.A. Dolhan
Environmental Protection Section
Protective Sciences Division

DEFENCE RESEARCH ESTABLISHMENT OTTAWA
TECHNICAL NOTE 90-1

PCN
051LC

September 1989
Ottawa

ABSTRACT

Two fabrics, a polyester/cotton fabric laminated with Goretex, and a nylon fabric coated with Dermoflex, were proposed for the prototype Arctic clothing system. Samples of each fabric were subjected to various physical tests, both before and after laundering, at room temperature and at -40°C to determine the durability of the fabrics. Prototype garments made of the nylon fabric were laundered to determine the durability and effects of laundering on the construction. Donning and doffing of the prototype system was performed at 0°C and at -40°C.

RESUME

Deux matériels, un de polyester/cotton laminé de Goretex et un autre de nylon recouvert de Dermoflex, ont été proposés pour le prototype du système de vêtements d'Arctique. Des échantillons de chacun des matériels furent soumis à divers épreuves physiques, avant et après lavage, à la temperature de la pièce et à -40°C pour déterminer la durabilité des matériels. Des vétements prototypes faits de nylon furent lavés pour determiner le durabilité et les effets du lavage sur la construction du vétement. L'habillement et le déshabillement avec prototype furent faits à 0°C et à -40°C.

EXECUTIVE SUMMARY

A new prototype Arctic clothing system has been proposed for the Canadian Forces (CF). This clothing system must protect the soldier in a variety of weather and work conditions. It must keep the soldier warm while he is performing sentry duty at -40°C, yet protect him while he is marching through the bushes carrying a 40 kg pack at 0°C. For a clothing system to stand up to these opposing conditions, the fabric must stand up to strenuous assaults and the seams must not fall apart at inopportune times.

Two candidate fabrics, which are waterproof yet allow water vapour (sweat) to pass through, a polyester/cotton laminated with Goretex and a nylon fabric coated with Dermoflex were subjected to various physical tests, both before and after laundering up to 20 times using a technique which approaches that of field laundering, at room temperature (20°C) and in the extreme cold (-40°C).

The two fabrics yielded very similar results under test conditions. Both fabrics shrunk after laundering, however both remained within the acceptable limits set for fabric shrinkage. The waterproofness and the ability to allow water vapour to pass through was within the same range for both fabrics and did not change after laundering.

Neither fabric was stained appreciably by oil, and both fabrics resisted penetration by a variety of different chemicals.

The tearing strengths and breaking strengths of the two fabrics are similar and did not change in the extreme cold.

As the nylon fabric was finished with a fire retardant finish, this fabric performed much better than the Goretex fabric when exposed to the most severe flammability test.

The prototype cold weather clothing system was laundered to determine the effects of laundering on the garment and the durability of the construction. The outer parka became 50% thicker when laundered 20 times and the seams shrunk, but again within the acceptable limits.

The strength of the seams was determined and found to meet the minimum strength requirements.

The time required to don the four piece prototype cold weather clothing system at 0°C was one minute and thirteen seconds. It took 42 seconds to doff the complete system. At -40°C it took two minutes and 52 seconds to don and one minute to doff the clothing. The zippers and the neck closures caused the most problems for the soldiers when donning and doffing.

TABLE OF CONTENTS

ABSTRACT iii

RESUME iii

EXECUTIVE SUMMARY v

1.0 INTRODUCTION 1

2.0 EXPERIMENTAL ANALYSIS 2
- 2.1 PHYSICAL TESTS PERFORMED 2
- 2.2 DIMENSIONAL CHANGE 2
- 2.3 WATER VAPOUR PERMEABILITY 3
- 2.4 HYDROSTATIC HEAD PENETRATION 4
- 2.5 OIL REPELLENCY 4
- 2.6 TEARING STRENGTH 4
- 2.7 BREAKING STRENGTH 5
- 2.8 FLAMMABILITY 6
- 2.9 PENETRATION RESISTANCE 6
- 2.10 PHYSICAL TESTING OF THE COLD WEATHER PARKA 7
- 2.11 SEAM STRENGTH 8
- 2.12 DONNING AND DOFFING 3

3.0 SUMMARY 10

4.0 CONCLUSIONS 11

5.0 REFERENCES 11

APPENDIX A 12

APPENDIX B 13

1.0 INTRODUCTION

A new prototype Arctic clothing system has been proposed for the Canadian Forces (CF). This clothing system is designed to protect the soldier in a variety of weather and work conditions (1). The fabric and construction used for the clothing system must therefore be durable so the soldier is protected at all times.

Samples of two candidate fabrics (Table 1) were submitted to various tests to determine the durability and the suitability of the fabrics for Arctic clothing. Both the fabrics have a hydrophillic top coat applied to prevent leakage at high pressure points.

The durability of the construction techniques was observed by noting the effect of laundering on a prototype garment made up from one of the candidate fabrics.

The ease with which a clothing system is donned and doffed is an important consideration when designing for cold weather. The time taken to don and doff the prototype clothing system at 0°C and at -40°C was determined with the assistance of members of the DREO Test Team.

TABLE 1: PHYSICAL PROPERTIES OF THE FABRICS

Trade Name & Manufacturer	Fibre Content	Coating	Thickness (mm)	Mass (g/m^2)	Yarn Count (warp x weft /cm)
Goretex W.L. Gore & Ass. Elkton, Maryland	65% Polyester 35% Cotton	Goretex (Microporous PTFE* film)	0.47	175	40 x 25
Linebacker Consoltex, Alexandria, Ontario	100% Nylon	Dermoflex (Microporous polyurethane)	0.23	208	27 x 20

* Polytetrafluoroethylene

2.0 EXPERIMENTAL ANALYSIS

2.1 PHYSICAL TESTS PERFORMED

The fabrics were subjected to several tests both before and after laundering, and at various temperatures to observe the performance of the fabrics in simulated field use. The tests performed are listed in Table 2.

The ability of the fabrics to resist penetration by various chemicals was performed by the Texas Research Institute, Austin Texas, for UCB Chemicals Ltd., Norfolk Virginia, and then submitted to Consoltex. Both Goretex laminated fabric and Dermoflex coated fabrics were subjected to the penetration tests.

TABLE 2: PHYSICAL TESTS PERFORMED

Physical Property	Test Method
Laundering	CGSB Method 58, Procedure IV (wash), Procedure E (dry)
Dimensional Change	CGSB Method 58
Water Vapour Permeability	modification of new CGSB Method 49
Hydrostatic Head	CGSB Method 26.3
Oil Repellency	modification of AATCC 118-1966
Tearing Strength	CGSB Method 12.3
Breaking Strength	CGSB Method 9.1
Flammability	CGSB Method 27.3
Penetration Resistance	ASTM Method F903
Seam Strength	ASTM Method D1682-64

2.2 DIMENSIONAL CHANGE

Both fabrics were laundered and tumble dried. Measurements were taken after 1, 5, 10, and 20 launderings and given in Table 3.

The Linebacker fabric shrank progressively up to 2% with repeated launderings. The amount of shrinkage did not increase after 10 launderings.

The Goretex fabric shrank progressively, and continued to shrink up to 4% with 20 launderings. The shrinkage for both fabrics is within the acceptable limit of 5%.

TABLE 3: DIMENSIONAL CHANGE

% Change

Launderings		Linebacker	Goretex
1	warp	-1.3	-1.8
	weft	-1.1	-1.6
5	warp	-1.8	-2.8
	weft	-1.2	-2.4
10	warp	-2.4	-3.6
	weft	-1.9	-3.1
20	warp	-2.2	-3.9
	weft	-1.4	-3.5

2.3 WATER VAPOUR PERMEABILITY

The water vapour permeability of the fabrics before and after laundering was measured on the apparatus presently used at DRTO. It is similar in operation to the apparatus that is described by van Beest and Wittigen (2).

The water vapour resistance of the specimens was measured film side down, at both 6 mm and 2 mm from the water surface. It has been shown that for fabrics coated with a hydrophillic top coat, the relative humidity of the sample greatly influences its water vapour resistance (3). The water vapour resistance of both fabrics is comparable as shown in Table 4, and quite acceptable for coated fabrics.

Laundering did not appear to affect the permeability of either the Goretex or Linebacker fabrics.

TABLE 4: WATER VAPOUR PERMEABILITY

mm equivalent still air

	Linebacker		Goretex	
Launderings	6 mm	2 mm	6 mm	2 mm
0	14.1 ± 0.6	15.2 ± 2.1	26.3 ± 1.8	14.9 ± 1.3
1	20.1 ± 0.1	17.8 ± 0.4	31.2 ± 0.6	18.4 ± 0.6
5	19.9 ± 0.5	16.2 ± 0.2	26.8 ± 0.4	12.6 ± 0.2
10	18.7 ± 0.4	17.1 ± 0.5	28.4 ± 0.4	15.8 ± 0.1
20	20.5 ± 0.2	13.8 ± 0.2	27.3 ± 1.3	13.3 ± 0.4

2.4 HYDROSTATIC HEAD PENETRATION

This test determines the resistance of the fabrics to penetration by water under pressure. A specimen held in a horizontal position is subjected to pressure from a column of water whose height increases at a constant rate. The hydrostatic pressure at which leakage occurs is indicated by the height of the column of water. Both fabrics, tested film side down, resisted penetration to over 100 cm of water (the maximum height possible with our apparatus) before and after laundering.

2.5 OIL REPELLENCY

The ability of the fabrics to resist wetting by an oily liquid is determined using AATCC Method 118-1966. Liquid hydrocarbons of varying surface tensions are dropped onto the fabric, and the fabric is observed for wetting. The oil was dropped onto the fabric side of the Linebacker and Goretex samples. The oil repellency rating is the highest-numbered test liquid which does not wet the fabric surface. The higher the oil repellency rating, the better the resistance to staining. Liquid #1 is Nujol, and liquid #6 is n-decane. The results of this test are given in Table 5.

The change in rating of the Goretex sample is thought to be caused by a detergent residue on the fabric.

TABLE 5: OIL REPELLENCY

Laundering	Linebacker	Goretex
0	6	1
10	6	6

2.6 TEARING STRENGTH

The tearing strength of the fabric is determined by the force required to propagate a small cut in the fabric. The Linebacker and the Goretex fabrics had similar tearing strengths, and neither changed appreciably in either cold or wet conditions (Table 6). Only one sample was tested wet.

TABLE 6: TEARING STRENGTH IN N

-40°C	Linebacker	Goretex
warp	21.7 ± 0.5	20.0 ± 1.0
weft	15.7 ± 0.3	26.9 ± 1.3
20°c		
warp	22.5 ± 1.1	21.0 ± 0.2
weft	20.3 ± 0.6	17.2 ± 0.3
wet		
warp	22.0	23.9
weft	15.7	25.1

2.7 BREAKING STRENGTH

Breaking strength is the maximum tensile force observed during a test in which the specimen is stretched until it breaks, as shown in Table 7. The Linebacker fabric is stronger in both the warp and weft directions than the Goretex fabric. Both fabrics have a higher breaking strength at -40°C than at 20°C.

TABLE 7: BREAKING STRENGTH IN kN

-40°C	Linebacker	Goretex
warp	0.74 ± 0.08	0.51 ± 0.02
weft	0.57 ± 0.07	0.44 ± 0.01
20°C		
warp	0.57 ± 0.01	0.40 ± 0.01
weft	0.42 ± 0.01	0.30 ± 0.01

2.8 FLAMMABILITY

The Linebacker and Goretex fabrics were subjected to the most severe flammability test. The samples are held vertically in a frame. The lower edge of the fabric is held in the flame for 12 seconds. The flame is then removed, and the fabric is observed for after-flame, and after glow, and the char length is measured once the test is completed.

The Linebacker burned with flame while in the direct flame. Once the fabric burned away from the ignition flame the fabric self-extinguished. The fabric continued to melt until the ignition source was removed. The exposed surface of the Goretex burned with dripping for 50s once the source of ignition was removed. The face fabric burned at a faster rate than did the tricot backing. It must be noted that the Linebacker had been treated with a fire retardant coating. The timed results are in Table 8.

TABLE 8: FLAMMABILITY, VERTICAL BURNING TEST
after 10 launderings

	Linebacker	Goretex
After-flame	0 s	50 s
After-glow	0 s	0 s
Average Char	12 cm	30 cm

2.9 PENETRATION RESISTANCE

ASTM Method F903 determines the resistance of protective clothing materials to visible penetration under the condition of continuous liquid contact. This method specifies chemical contact with the material sample for 5 minutes at ambient pressure, and 10 minutes contact at 6.9 KPa (1 psig). Observation of liquid penetration at any time during the 15 minute contact period constitutes failure of the material sample to resist penetration by the challenge chemical.

A modified form of the ASTM penetration test method proposed in draft NFPA 1992, "Standard on Liquid Splash-Protective Clothing for Hazardous Chemical Emergencies", is used for testing protective suit materials, and was used on the fabrics submitted for testing. The exposure times and the pass/fail criteria are as follows:

5 minutes contact at ambient pressure
1 minute contact at 13.8 KPa (2 psig)
54 minutes contact at ambient pressure

Observation of liquid penetration at any time during the one hour contact period constitutes failure of the material sample to resist penetration by the challenge chemical.

The fabrics tested for UCB Chemicals Ltd. by Texas Research Institute are similar to the fabrics used in the other tests, but are not necessarily the same fabrics. The test results are given in Table 9.

TABLE 9: PENETRATION RESISTANCE RESULTS

CHEMICAL	DERMOFLEX/ LINEBACKER	DERMOFLEX/ NOMEX	GORETEX/ NOMEX
Acetone	pass	pass	pass
Acetonitrile	pass	pass	fail
Dimethylformamide	fail	fail	pass
Ethyl Acetate	pass	pass	pass
Hexane	pass	fail	pass
Methanol	pass	pass	pass
Sodium Hydroxide (50%w/w)	pass	pass	pass
Sulfuric Acid (96%)	fail	fail	fail
Toluene	pass	pass	pass

2.10 PHYSICAL TESTING OF THE COLD WEATHER PARKA

The prototype DREO cold weather clothing system consists of 4 garments, an inner parka, inner trousers, outer parka and outer trousers. The outer fabric of the first three garments is Linebacker coated with a fire retardant, Dermoflex. The outer parka is insulated with 271 g/m^2 (8 oz/yd^2) polarguard. The thickness of the outer parka was measured under 45 Pa pressure both before laundering and after 1, 5, and 10 launderings to determine if there was any change in the thickness of the insulating layer. As can be seen in Table 10, the parka increased in thickness substantially, up to 50% of the original thickness. This is thought to be due to fabric and seam shrinkage. To determine seam shrinkage, the length of the sleeve seam was measured before and after laundering. Table 10 shows that the seams did shrink but no more than the fabric.

TABLE 10: CHANGE IN PHYSICAL PROPERTIES ON LAUNDERING

Launderings	Thickness (cm)	% Change
0	2.6	-----
1	3.0	15.4
5	3.4	30.8
10	3.9	50.0

Launderings	Sleeve Seam Length (cm)	% Change	Side Seam Length (cm)	% Change
0	20.1	----	19.5	----
1	19.8	-1.5	19.0	-2.6
5	19.5	-3.0	19.2	-1.5
10	19.4	-3.5	18.5	-5.1

2.11 SEAM STRENGTH

The seam to be used in most of the clothing is a double-lap seam which is known to be one of the strongest seams commonly used. Studies at DREO (4) have concluded that seams in clothing intended for severe use should have a minimum seam strength of 1.5×10^4 N/m (as measured according to ASTM Method D 1682-64 (Reapproved 1975) "Standard Methods of Test for Breaking Load and Elongation of Textile Fabrics").

ADGA (DREO's contractor for constructing the prototype garments) supplied us with double-lap seams which had been sewn in the Linebacker fabric and subsequently heat sealed. Using the grab test of the above-mentioned ASTM test method, eight seamed and taped specimens, 100 mm wide were broken, using 25 mm wide jaws, placed 75 mm apart in a time of 20 ± 3s. The breaking load was 1.6×10^4 N/m with a coefficient of variation of 6%. Thus it is possible to achieve the required minimum seam strength. Subsequent wear trials showed no problems with broken seams (5). For the record, the % seam extension was 15.7%, with a coefficient of variation of 6%.

2.12 DONNING AND DOFFING

Donning and doffing of the Arctic clothing system (the complete system is outlined in Appendix A) was performed at room temperature and at -40°C by the CF test team members. All the clothing made was medium size, in short, regular

and tall. Two test team members wore regular size clothing, one tall size and two short size.

The protocol followed for performing the donning and doffing tests using the CF Test Team is outlined in Appendix B. All members started with the pile liner trousers and jacket on and done up. The inner trousers were then put on and done up. The inner parka was then put on, the waist drawstring tightened, the zipper and buttons done up, the bottom drawstring tightened, the hood put on and the neck closure done up. The mukluks were then put on. The outer trousers were then put on over the mukluks. The suspenders which had been left attached to the trousers for each donning and doffing trial were then put on. The outer parka was put on, the zipper and buttons done up, the hood put on and the neck closure done up. Mitts were the final item donned.

The average times to don and doff each article of clothing are listed in Table 11. A learning curve was established for each test team member at 0°C. For all members, four trials were sufficient to reach a plateau. The times quoted are an average of the final times of each of the test team members.

TABLE 11: AVERAGE TIME TO DON AND DOFF THE PROTOTYPE CLOTHING SYSTEM in s

	DON		DOFF	
	0°C	-40°C	0°C	-40°C
INNER TROUSERS	10.4	15.0	11.4	17.3
INNER PARKA	27.5	45.2	11.4	10.8
OUTER TROUSERS	47.4	49.9	10.6	19.0
OUTER PARKA	27.4	53.3	9.1	11.9
TOTAL	113.0	172.4	42.5	59.0

The outer parka took the most time for both donning and doffing in the cold. This garment required more work to completely do up than did the other garments and by this time the mens' fingers were quite cold. The zippers and the neck closures consumed the most time in donning and doffing both the parkas. A two way reversible zipper is used in the parkas. In the current design there is no need for the zipper to be reversible, as the garment will never be worn inside-out. A two way separating zipper would be sufficient, and would reduce

the awkwardness of the task. Velcro instead of buttons at the neck closure would make closing the neck of the parkas much easier. In the cold, the task of doing these buttons up would be almost impossible.

3.0 SUMMARY

Several physical tests were performed on a Goretex laminated polyester/cotton fabric, and on a nylon fabric coated with Dermoflex to determine the suitability and durability of the fabrics for use in Arctic clothing. The test results for the two fabrics are very similar.

Shrinkage for both fabrics was within the acceptable limits of 5% after 20 launderings. Laundering did not appear to affect the water vapour permeability of either fabric. The water vapour permeability of the Linebacker fabric remained at approximately 20 and 16 mm equivalent still air for a 6 mm air gap and a 2 mm air gap respectively. The Goretex fabric remained at 27 and 16 mm equivalent still air for the same air gaps. The hydrostatic head penetration remained at over 100 cm for both fabrics before and after repeated home launderings.

Linebacker and Goretex fabrics resisted staining by oil after repeated launderings. Sulfuric acid was the only chemical that penetrated both Goretex laminated and Dermoflex coated fabrics. Dimethylformamide penetrated Dermoflex coated fabrics, while Acetonitrile penetrated Goretex laminated fabrics. Both fabrics resisted penetration to all other chemicals tested.

Temperature did not seem to affect the tearing strength or breaking strength of either fabric tested. The tearing strength of both fabrics was approximately 20 N at both 20°C and -40°C. The breaking strength of both fabrics was approximately 0.5 kN at both temperatures.

The Linebacker fabric performed better in the vertical flammability test than did the Goretex fabric. This is due to the fact that the Linebacker fabric was treated with a fire retardant finish.

Laundering the prototype cold weather outer parka made of Linebacker caused a 50% increase in the thickness of the parka. The seams of the parka shrunk, but were within the 5% limit.

The seams used in the clothing system were double lap seams. The breaking strength of these seams met the minimal seam strength for clothing intended for severe use.

Donning and doffing of the four piece prototype Arctic clothing system was performed at 0°C and at -40°C. The total time to don the four piece system at 0°C was one minute thirteen seconds. At -40°C donning took two minutes fifty-two seconds. Doffing was performed in 42 seconds at 0°C, and 59 seconds at -40°C. The outer parka was the most time consuming article of the system for

both donning and doffing in the cold. The zippers and neck closures caused the most problems for the soldiers while donning and doffing.

4.0 CONCLUSIONS

Either the Linebacker or Goretex fabric would be suitable for the Arctic clothing system. Both fabrics have very similar characteristics with respect to the tests performed, with the exception of flammability, where the Linebacker was superior due to its fire retardant coating.

5.0 REFERENCES

1. J.B. Cain, B. Farnworth, R.J. Osczevski, CDA 3, A Cold Weather Clothing System: Concept and Theoretical Considerations, Presented to the 15th Commonwealth Defence Conference on Operational Clothing and Combat Equipment, 1989.

2. C.A. van Beest, P.P.M.M. Wittgen, A Simple Apparatus to Measure Water Vapor Resistance of Textiles, Textile Research Journal, p. 566-568, Sept. 86.

3. B. Farnworth, W.A. Lotens, P.P.M.M. Wittgen, The Variations of Microporous and Hydrophillic Films with Relative Humidity, Submitted for publication to the Textile Research Journal.

4. R.M. Crow, M.M. Dewar, Stresses in Clothing as Related to Seam Strength, Textile Research Journal, Vol. 56, # 8, Aug. 86.

5. Concept Evaluation Report, Cold Weather Clothing, Combat Training Centre, CFB Gagetown, 1989.

APPENDIX A

DREO WINTER CLOTHING SYSTEM

The clothing system developed at Defence Research Establishment Ottawa consists of the following items:

1. Pile Liner, Jacket

   - Nylon/polyester pile fabric
   - manufactured by Helly-Hansen

2. Pile Liner, Trousers

   - As pile liner, jacket

3. Inner Parka

   - Waterproof, "breathable", fire retardant, DERMOFLEX coated nylon with fire-retardant NOMEX liner

4. Inner Trousers

   - As inner parka

5. Outer Parka

   - Same waterproof fabric as inner parka
   - POLARGUARD insulation

6. Outer Trousers

   - Windproof but not waterproof fabric
   - POLARGUARD insulation
   - Suspenders

7. Mitts

   - CF issue Arctic mitts

8. Mukluks

   - CF issue Mukluks

APPENDIX B

PROTOCOL FOR DONNING AND DOFFING

1. Ensure that all clothing is "workable" and all parts available.

2. Accustom subjects to donning and doffing of clothing as instructed and repeat in comfortable surroundings until times plateau.

3. Have the subjects rest for 30 minutes in "undressed" or "dressed" state and then time the donning and doffing until times plateau.

4. In cold, have the subjects in sleeping bag for 30 minutes in "undressed" state then time the donning until times plateau.

5. In cold, have the subjects resting in "dressed" state for 30 minutes and then time for doffing the clothing until times plateau.

6. If "2" is done then "3", "4", and "5" should only have 1 repeat.

7. More than one subject can be done at a time if entry times are scattered.

8. Conduct only one test per morning per subject and then repeat in the afternoon or next day for "3", "4", and "5".

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Establishment sponsoring a contractor's report, or tasking agency, are entered in section 8.)

Defence Research Establishment Ottawa
National Defence
Ottawa, Ontario K1A 0Z4

2. SECURITY CLASSIFICATION (overall security classification of the document. including special warning terms if applicable)

UNCLASSIFIED

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C or U) in parentheses after the title.)

COMPARISON OF GORETEX LAMINATED AND DERMOFLEX COATED FABRICS (U)

4. AUTHORS (Last name, first name, middle initial)

DOLHAN, P.A.

5. DATE OF PUBLICATION (month and year of publication of document)

SEPTEMBER 1989

6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)

18

6b. NO. OF REFS (total cited in document)

5

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

DREO TECHNICAL NOTE

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address.)

Defence Research Establishment Ottawa
National Defence
Ottawa, Ontario K1A 0Z4

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant)

051LC

9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written)

10a. ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

DREO TECHNICAL NOTE 90-1

10b. OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor)

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

(X) Unlimited distribution
( ) Distribution limited to defence departments and defence contractors; further distribution only as approved
( ) Distribution limited to defence departments and Canadian defence contractors; further distribution only as approved
( ) Distribution limited to government departments and agencies; further distribution only as approved
( ) Distribution limited to defence departments; further distribution only as approved
( ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availabilty (11). However, where further distribution (beyond the audience specified in 11) is possible, a wider announcement audience may be selected.)

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM

13. ABSTRACT (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), or (U). It is not necessary to include here abstracts in both offical languages unless the text is bilingual).

Two fabrics, a polyester/cotton fabric laminated with Goretex, and a nylon fabric coated with Dermoflex, were proposed for the prototype Arctic clothing system. Samples of each fabric were subjected to various physical tests, both before and after laundering, at room temperature and at -40°C to determine the durability of the fabrics. Prototype garments made of the nylon fabric were laundered to determine the durability and effects of laundering on the construction. Donning and doffing of the prototype system was performed at 0°C and at -40°C.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

BREATHABLE FABRICS
COLD WEATHER CLOTHING
TEST METHODS
LOW TEMPERATURE TESTS